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PHYSICAL AND CHEMICAL CONTROL OF INSECTS

Progress Report of the Sanitary Engineering Research Committee, Public Health Engineering Section

SANITARY ENGINEERING DIVISION

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THIS PAPER

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SED RESEARCH REPORT NO. 2

ON PHYSICAL AND CHEMICAL CONTROL OF INSECTS

BY The Sanitary Engineering Research Committee, Public Health Engineering Section.

From Research Data of S. S. Block, Associate Professor of Chemical Engineering, University of Florida, Gainesville.

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Synopsis: The effectiveness of several types of screening and of residual insectidices incorporated in surface-protective coatings are reported. The results are based on field and laboratory tests.

INTRODUCTION

Insects are of considerable public health importance in serving as vectors for the transmission of the causative agents of a large number of communicable diseases. Flies and mosquitoes are known to be the vehicles of infection of certain diseases including malaria, yellow fever, dengue, filariasis, encephalitis, diarrheas, dysenteries, typhoid fever, cholera and yaws; and are suspected of being the culprits in several others. The only permanent method of controlling some of these diseases is to eliminate, or make untenable, the breeding and resting places of their insect vectors. Supplementary to the permanent control measures are local measures which prevent the adult insects from reaching their human victims. Two of the most effective local measures are screening and the use of residual insecticides. The studies reported herein compare the efficiencies of three types of screening and describe the mechanism and effectiveness of residual insecticides incorporated in surface-protective coatings.

Insects used in the laboratory testing include the common housefly, *Musca domestica*; the common Southern house mosquito, *Culex quinquefasciatus* (also an important vector of filariasis in some parts of the world); the common Eastern malaria mosquito, *Anopheles quadrimaculatus* and the yellow-fever and dengue carrier, *Aedes aegypti*. All of these insects were raised in the laboratory from eggs. For the screen tests, an undersized *Aedes aegypti* was produced by overcrowding and underfeeding the larvae.

Control by Screening

Experimental Procedure

Several sizes of woven-wire screening and one size of louver-type screening were used in the tests. All of the woven mesh was manufactured of standard 0.011-inch diameter wire and had the characteristics shown in the tables. The louver-type screen is intended to serve the dual purpose of screening out insects and a portion of the sunlight while permitting ventilation. A standard brand was used in which parallel openings were pierced through 0.008-inch thick sheet aluminum. The dies were designed to make parallel cuts 0.05-inch apart and the resulting louvers stand out at an angle of 33° from the vertical. Openings measure 0.047-inch by 0.78-inch long and are spaced on 1-inch centers.

Laboratory tests of screening efficiency were made using mosquitoes as the test insects. The screening to be tested was made into cages 12 inches by 5 inches by 2 inches. A number of mosquitoes was put inside, and the cage placed in a museum jar covered with cheesecloth. After 48 hours, the insects were killed with ethylene dichloride and the percentage which had escaped from the cage to the outer jar was recorded.

Field test cages were made 2 feet by 2 feet by 2 feet with four sides screened and the top and bottom solid. A 15-watt light bulb, and a live chicken were placed inside the cage to serve as attractants. Inside the cage, but surrounding the attractants, were placed parallel charged wires at a spacing of 0.1-inch to electrocute and hold insects which passed through the screen. Field test cages were mounted a few feet off the ground in a forest clearing near a small lake. Each day the insects inside the cage were counted, identified and measured by means of a calibrated microscope.

Results

Results of six laboratory tests using a total of 682 normal size <u>Aedes aegypti</u> are shown in the first part of Table I. The second part shows the

Table I

Screen Mesh wires/inch Nominal	Actual	Mean Dimension of Openings mm.	Percentage Escaping
Louver	1.0 x 17.8	22.2 x 1.22	22.0
16 x 16	16.0 x 16.0	1.30 x 1.30	8.7
18 x 18	18.4 x 18.4	1.10 x 1.10	2.8
	<u>A. aegypti</u> - undersized		
16 x 16	16.0 x 15.0	1.30 x 1.41	50 ± 6
18 x 14	18.0 x 14.6	1.13 x 1.46	28 ± 6
18 x 18	18.0 x 18.7	1.13 x 1.08	6 ± 2

results using the undersize Aedes aegypti. No Anopheles and few Culex were able to penetrate any of the screens tested.

A summary of seven days of field test results is shown in Table II. Physical dimensions of the screen were indicated previously.

Table II

Nominal Screen Mesh	Total Insects Passed	Mean Dimension of Insects Collected Width mm.	Length mm.	Width Largest Insect mm.
Louver	2377	0.52	3.68	1.13
16 x 16	1475	0.32	2.60	0.88
18 x 18	1215	0.33	2.74	1.08

A breakdown of the insects invading the screened cages in the field tests indicated that there were many rove beetles, leaf hoppers and midges; but relatively small numbers of twelve other families of small insects. No mosquitoes penetrated the mesh screening and only five penetrated the louver screening in seven days.

Control by Insecticidal Surface Coating

Experimental procedure

Test cages, 5 inches by 5 inches by 5 inches were constructed with five faces treated with the test coating and the sixth covered by a sheet of transparent plastic. The plastic face had a stoppered 1-inch hole for introducing the test insects and was fastened in position with a rubber band.

Initially, laboratory-raised houseflies and mosquitoes were used in the tests. It was observed that the knockdown time was about the same for all groups, and Musca domestica was used for all subsequent tests. After the treated surfaces of the cages had set, 25 to 50 adult flies of the same age were introduced through the stoppered opening and the cages placed with the transparent side up. It was noted that the flies did not spend much time on the inverted cover. The time was noted when a 50 per cent knockdown occurred. Interval exposures were made by retaining the flies in a treated box for a fixed period, then transferring them to an untreated box and noting the time for 50 per cent knockdown.

Tested were various coating vehicles containing DDT but no pigment, various coating vehicles with DDT and titanium dioxide pigment and coating vehicles with several insecticidal materials. The treated cages were tested periodically after the initial experiments to determine the residual effectiveness.

Results

A summary of the effectiveness of coating vehicles containing 20 per cent DDT is given in Table III.

The effect of time after application and varying concentrations of DDT in the vehicle is shown in Table IV.

Table III

Coating Vehicle Type	Time for 50% Knockdown (minutes) Initial	After interval	Interval Between Tests (weeks)
Asphalt varnish	13	7	6
Urea-formaldehyde	10	8	1
Melamine-formaldehyde	38	12	2
Vegetable wax (Carnauba)	23	12	4
Modified alkyd	30	15	10
Rosin-modified maleic ester	30	18	2
Nitrocellulose	60	18	1
Cellulose acetate	120	18	4
Casein	32	18	26
Shellac	75	20	26
Fatty acid-ethylene diamine	28	20	4
Polyvinyl acetate-chloride	150	22	26
Phenolic	35	22	4
Beeswax	30	23	4
Polymerized diolefin	21	32	4
Modified phenolic	71	40	4
Alkyd emulsion	120	42	78
Sodium silicate	65	50	26
Paracourmarone-indene	220	64	26
Linseed-tung oil	450	160	104
Chlorinated rubber	35	180	4
Portland cement	15	-	-

Table IV

Coating Vehicle Type	Weeks After Application	Time for 50 per cent Knockdown — Per cent DDT (dry basis) 1	5	10	15	20	50	90
Linseed-tung oil	0	>1080	720		420	450		90
	30				225			50
	60	>420	420					20
	104	>420	330		215	160		22
Urea-formaldehyde	0	40		29		16	11	
	2	40		9		8		
	8	36		8		8		
	28	22		8		10	10	
Nitrocellulose	0	>1440	210	160		60	38	
	35		190	32		17	12	
	65		290			18	13	
Casein	0	56	41	56		32		
	26	66	43	20		18		
	60	33	29	21		15		
Paracourmarone-indene	0	270	270			220	145	
	26	210	180			64	28	
	56	180	83			36	26	

The effectiveness of different types of insecticidal chemicals in several of the vehicles is shown in Table V. Each insecticide was present in a 20 per cent concentration based on the dry weight of the coating.

For certain types of vehicles, the effectiveness of the included insecticides is increased greatly by the presence of pigment as indicated in Table VI.

Table V

Coating Vehicle Type	Insecticide	Time for 50% Knockdown (minutes) Initial	After Interval	Interval Between Tests (weeks)
Urea-formaldehyde	DDT	16	10	28
	Benzene hexachloride	13	16	6
	Chlordane	60	41	7
	Toxaphene	48	35	12
	DDD	28	25	17
	Pyrethrum	18	2,11,23,52	8,14,15,17 days
Nitrocellulose	DDT	60	17	35
	Benzene hexachloride	39	20	30
	Chlordane	76	28	30
	Toxaphene	55	26	12
Polymerized diolefins	DDT	21	32	6
	Benzene hexachloride	20	23	6
	Chlordane	71	29	30

For certain types of vehicles, the effectiveness of the included insecticides is increased greatly by the presence of pigment as indicated in Table VI.

Table VI

Coating Vehicle	Per cent DDT in Dry Coating	Per cent Pigment in Dry Coating	Time for 50 Per cent Knockdown (minutes)
Linseed-tung oil	20	0	270
	20	20	270
	20	60	24
	20	70	13
Nitrocellulose	20	0	17
	20	60	15
Silicate	20	0	50
	20	60	24
Urea-formaldehyde	1	0	22
	1	60	29

Discussion

All of the screening tested was effective against penetration of the larger and medium-sized mosquitoes and would thus certainly exclude adult houseflies. The louver screen, which was shown to be the least effective, still excluded about 4/5 of the mosquitoes. The insects which passed the louvers were found to be somewhat undersized Aedes aegypti. Although none of the intentionally-developed undersized A. aegypti were used in testing the louver screen, it is likely that this screen would not offer an effective barrier against the passage of such insects. This would appear to be an important factor in the selection of screen mesh, since, under natural conditions, vagaries of the weather and shortages of food could possibly result in the development of numbers of undersized mosquitoes.

The 18 x 14 mesh which was tested was a development of the screening industry to replace the 16 x 16 mesh. An appreciable increase in output was possible with the 18 x 14 because only 14 strokes of the shuttle were required per inch instead of 16. About the same amount of material was required per square foot for each size. With the undersized A. aegypti, the 18 x 14 was shown to be more effective than the mesh it replaced. For normal size mosquitoes there was no appreciable difference.

Since the female mosquito is the only one capable of biting humans and thus spreading disease, a study was made of the percentage of males penetrating the screen as compared with females. No significant difference was noted.

It will be noted from the results on the insecticides that, in most cases, the toxicity of the coatings was not constant but definitely increased with age. The time required to develop maximum toxicity was found to vary with the vehicle, but it was generally observed that the more toxic coatings developed maximum effectiveness in a relatively short time. The mechanism of this aging phenomenon is believed to be the gradual precipitation of the insecticide from a supersaturated state in the vehicle. Thus the surface coating vehicles act as reservoirs to replace the toxic material at the surface as it is wiped off or volatilized.

The rate of transfer to the surface is of considerable importance. In general, oil or oil-modified resin vehicles produced coatings which were rather poor in this respect. Many of the synthetics were outstanding in both toxicity and the time to develop the maximum toxicity when mixed with DDT.

For certain paint vehicles, the effectiveness of the DDT was enhanced by the addition of pigment. This may have been due to the action of the pigment particles in breaking the glossy surface film or, in the case of the oil vehicles, the pigment may have aided the absorption of oil with consequent chalking.

Studies comparing the effectiveness of several insecticides in surface coating vehicles gave varying results. This points up the need for further study of the effectiveness of each insecticide in a variety of paint vehicles.

CONCLUSIONS

The studies which have been reported support the following conclusions:

1. Confirm the practice of not using any screening material for mosquito control of larger than 16 x 16 mesh.

2. Louver screening may not be an effective barrier against the smaller mosquitoes.

3. The use of 5 to 20 per cent DDT or other insecticides in many types of paint may be an excellent way to provide a residual coating toxic to insects.

4. Dairy barns and similar structures may be painted with a chalky paint containing casein or portland cement and 1 to 5 per cent DDT to provide control of flies.

5. Incorporating insecticides in the plastic from which screens are woven could increase the overall effectiveness of the screening.

Credit

This research report, which is one of a series of professional contributions by the Committee on Sanitary Engineering Research,

	William T. Ingram	Air Pollution
	Herman R. Amberg	Stream Pollution
	Jess C. Dietz	Sewage
	Marvin L. Granstrom	Water
	E. R. Hendrickson	Public Health
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has been prepared by E. R. Hendrickson.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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c. Discussion of several papers, grouped by Divisions.